

Family list**14** family members for:**JP7258775**

Derived from 8 applications.

- 1 Copper alloy suited for electrical components and having high strength and high electric conductivity**
Publication info: **CN1042350C C** - 1999-03-03
CN1115789 A - 1996-01-31
- 2 Copper alloy suited for electrical components and having high strength and high electric conductivity**
Publication info: **GB2287716 A** - 1995-09-27
GB2287716 B - 1998-09-16
GB9505455D D0 - 1995-05-03
- 3 Copper alloy suited for electrical components and having high strength and high electric conductivity**
Publication info: **GB2311297 A** - 1997-09-24
GB2311297 B - 1998-09-16
GB9713358D D0 - 1997-08-27
- 4 HIGH TENSILE STRENGTH AND HIGH CONDUCTIVITY COPPER ALLOY FOR ELECTRONIC EQUIPMENT**
Publication info: **JP2764787B2 B2** - 1998-06-11
JP7258774 A - 1995-10-09
- 5 HIGH TENSILE STRENGTH AND HIGH CONDUCTIVITY COPPER ALLOY FOR ELECTRONIC EQUIPMENT**
Publication info: **JP7258775 A** - 1995-10-09
- 6 HIGH STRENGTH AND HIGH ELECTRICAL CONDUCTIVITY COPPER ALLOY FOR ELECTRONIC APPLIANCE**
Publication info: **JP7258776 A** - 1995-10-09
- 7 COPPER ALLOY SUITED FOR ELECTRICAL COMPONENTS AND HIGH STRENGTH ELECTRIC CONDUCTIVITY**
Publication info: **KR175968 B1** - 1999-02-18
- 8 Copper alloy suited for electrical components and having high strength and high electric conductivity**
Publication info: **SG30315 A1** - 1996-06-01

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(58) Field of Search

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(54) Copper alloy suited for electrical components and having high strength and high electric conductivity

(57) A Cu-Cr-Zr based precipitation-hardening type alloy is improved to be suited for electrical components, required to exhibit improved, strength, electric conductivity, cyclic bending formability, soldering property, reliability of soldered portion, Ag plating property, press-blanking formability, and non-occurrence of burr. The alloy composition is 0.05-0.40% of Cr, 0.03-0.25% of Zr, 0.0005-less than 0.01% of S, from 0.05 to 2.0% of Zn, optionally from 0.01 to 1% in total of at least one element selected from Sn, In, Mn, P, Mg and Si, and/or optionally from 0.10 to 0.80% of Ti together with 0.10 to 1.80% Fe, where the Fe/Ti weight ratio is from 0.66 to 2.6 in a range of from 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 2.6 in a range of more than 0.60 to 0.80% of Ti, and the balance of Cu and unavoidable impurities, and having an average grain size of 60 μ m or less and a microstructure comprising aging precipitates of a Zr-Cu compound, chromium and optionally a Ti-Fe intermetallic compound.

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COPPER ALLOY SUITED FOR ELECTRICAL COMPONENTS AND
HAVING HIGH STRENGTH AND HIGH ELECTRIC
CONDUCTIVITY

FIELD OF THE INVENTION

The present invention relates to a copper alloy which exhibits high strength and high electric conductivity as well as improved, chemical etching property and bending formability.

5 The copper alloy, to which the present relates, is suited for use as the electrical components, such as lead frame of semiconductor devices, e.g., transistors and integrated circuits (ICs).

BACKGROUND OF INVENTION

10 The trend of IC packages in recent years can be characterized by weight-reducing, thinning, shortening and narrowing. This trend is accelerated more and more along with the recent spread of surface packaging. Simultaneously, the IC packages are being provided with more pins and their heat
15 generation is lessened along with the functional increase of IC chips.

The structure of the IC packages has been changed and varied specifically as described as follows.

Conventionally, the pin-inserting package, which is
20 represented by the dual inline package (DIP), had been used frequently. This package has, however, been replaced more and more with such surface-packing types as the small outline J-lead package (SOJ), the small outline package (SOP), the quad flat package (QFP) and the like. As a result, the surface package
25 in the current trend of IC packages has very high packing density. Most recently, since the pins have been increased, QFPs with fine lead-pitch are more popularly used. In addition, reduction in sheet thickness is being promoted, as is represented by the thin small outline package (TSOP), thin quad flat package
30 (TQFP) and the like.

Incidentally, most of the leadframes with multi-pins and narrow pitch-gap is usually manufactured by means of chemical etching to groove a copper sheet in the direction of the thickness by corrosion. However, the corrosion results not only
35 in the intended grooving in the direction of the thickness also

in side etching in the direction of the width of the sheet. This means that a thinner sheet is more advisable with the view to forming accurate lead-width and lead gap. In order to meet the requirements for providing thin packages, it is necessary to reduce the thickness of the leadframe. Thickness of the copper sheets produced at present, therefore, tends to decrease from 0.15mm to 0.125mm and further to 0.1mm.

Attempts have been made to replace the etching with press forming. Remarkable improvements in fine press-forming techniques in recent years have supported these attempts. Although press forming is superior to etching, however, it would only partly replace etching.

In any event, the strength of leads is decreased due to reduction in thickness of the leadframe and width of the leads. The leads may, therefore, deform detrimentally during assembling and mounting of an electrical device. Materials of the leadframe should, therefore, have strength as high as possible so as to solve the problems as described above.

Furthermore, the power consumption of electrical devices increases along with enhancement in the integration degree of ICs and with increase in the number of pins of a package, with the result that heat generated from an IC chip necessitates measures to promote heat dissipation. Heat dissipation property of a leadframe is, therefore, an important factor.

In summary, various properties as follows are required for the material of the leadframe of semiconductor devices.

(a) High enough mechanical strength so that the leads of a leadframe are not easily deformed.

(b) Excellent chemical etching property and press formability so as to delineate the lead pattern of a leadframe.

(c) High enough heat conductivity so as to enable effective heat-dissipation from the IC chip being operated.

(d) Excellent electric properties, such as the Ag-added Cu has.

(e) Excellent soldering property for mounting a semiconductor device in a package. In addition, highly reliable solder-bonded portions are required.

(f) Excellent Ag-plating property required for bonding

of an IC chip and an inner lead.

(g) Oxidation resistance is so excellent that the material surface is not oxidized when subjected to a heating process, such as the soldering process

5 (h) Excellent cyclic bending property.

(i) Low price.

Both copper alloys, such as phosphorus bronze, and 42 Alloy (42 wt% Ni-Fe) exhibit a merit from the viewpoint of several aspects and a demerit from the viewpoint of other aspects. In
10 other words, the conventional materials do not satisfy all of the required properties mentioned above. Particularly, the conventional materials of a leadframe cannot be said to satisfactorily meet the properties required for strength, chemical etching property and bending formability, which should
15 be further improved along with the trend of the leadframe, that is, increase in the number of pins, more complicated shapes due to downsizing, and narrowing of the pin gaps.

In at least some of its embodiments the present invention seeks as a
20 first goal to provide a metallic material, which meets every one of the above mentioned properties required for the leadframe of semiconductor devices and the like, and which exhibits strength in terms of Vickers hardness of approximately 200 or more, corresponding to 65kgf/mm^2 or more of tensile strength,
25 50% or more of IACS (IACS: International Annealed Copper Standard where 100% IACS is equal to an electrical conductivity of 100% pure copper), corresponding to approximately 15 times higher than that of 42 Alloy, and improved bending formability and chemical etching property.

30 As a second goal also seeks the present invention/to provide a metallic material, which meets every one of the above mentioned properties required for the leadframe of semiconductor devices and the like, and, which exhibits 65kgf/mm^2 or more of tensile strength, 50%IACS or more, preferably approximately 70%IACS
35 and excellent bending formability and press-blanking formability.

As a third goal the present invention seeks to achieve the first goal and also to improve the press-blanking formability of the material.

The present inventor made a study to attain the first goal and arrived at the following conclusions.

Copper, which is the base material of the copper alloy, has heat conductivity far more superior to that of 42 Alloy. Copper alloys are, therefore, much more advantageous than non-copper materials for a leadframe in heat-dissipating property. In addition, the electric property, Ag-plating property, soldering property, oxidation resistance and elongation of the copper alloys can be maintained at a relatively good level as compared with those of 42 Alloy. Therefore, when strength, cyclic bending formability, and chemical etching property imparted to a copper alloy attains a level required for a thin leadframe, particularly having a thickness of from 0.10 to 0.15mm, and when the above mentioned, relatively good properties are not impaired, then the drawbacks of the conventional copper alloys can be eliminated, so that improved materials suited for the leadframe of semiconductor devices, a conductive spring and the like can be provided.

Based on the conclusion as above, the present inventor paid attention to the metallographic characteristics of the Cu-Cr-Zr alloy, which is one of the precipitation-hardening type copper alloys and hence can have high strength as compared with the solution-type copper alloys, without lessening the electric conductivity. As a result of research on the Cu-Cr-Zr alloy, the following discoveries are obtained.

(a) Cr and Zr are very effective elements for imparting high strength. In addition, Cr contributes to enhance the electric conductivity. However, the satisfactory strength required for a leadframe or an electro-conductive spring cannot be ensured only by addition of these elements. Addition of Ti and Fe is effective for further enhancing the strength.

(b) Although Ti and Fe are very effective for enhancing the strength of the copper alloy, the chemical etching property and electric conductivity are greatly influenced by their content. The addition of Ti and Fe should, therefore, be specified for the purpose of attaining good chemical etching property and electric conductivity. When the contents of the alloying components, i.e., Cr, Zr, Ti and Fe as well as the

ratio of alloying elements are strictly controlled in the copper alloy with the addition of Ti and Fe, various properties such as the strength, electric conductivity and chemical etching property can be balanced at a high level. Furthermore, when
5 the solution-treating temperature of the Cu-Cr-Zr alloy with the addition of Ti and Fe is so controlled to attain 60 μ m or less of average grain size, the bending formability can be balanced with the above specified properties at a high level.

(c) Addition of Zn, Sn, In, Mn, P, Mg or Si to the
10 above mentioned alloy in a specific amount can improve the reliability of the solder bonded portions and can further enhance the strength properties.

The present inventor made a study to attain the second goal and arrived at the following conclusions.

15 The copper-base alloys exhibit good heat conductivity and electric property. Their Ag-plating property, soldering property, oxidation resistance and elongation are relatively good as compared with 42 Alloy. Improved materials suited for the leadframe of semiconductor devices, a conductive spring and
20 the like can be realized, provided that strength, press-blanking formability and bending formability meet a level required for a thin sheet, while the above mentioned, relatively good properties are not impaired.

A study of the Cu-Cr-Zr alloy by the present inventor
25 revealed the following discoveries (d), (e) and (f).

(d) Cr and Zr are very effective elements for providing high strength. Cr also contributes to enhance the electric conductivity. Thoroughly satisfactory press-blanking formability suited for a leadframe in future cannot, however, be ensured
30 only by addition of Cr and Zr.

(e) Addition of sulfur (S) into the copper alloys has been heretofore avoided, because it would exert considerably detrimental influence upon the elongation. However, the S added to the Cu-Cr-Zr alloy at a strictly specified concentration out-
35 standingly improves the press-blanking formability, while incurring no practical detrimental influence upon the properties required for a leadframe, primarily, elongation. Such various properties as strength, electric conductivity and press-blanking

formability can be balanced at high level. In addition, the bending formability can be balanced with the other properties at a high level, when the average grain size is controlled to 60 μm or less.

- 5 (f) Addition of Zn, Sn, In, Mn, P, Mg or Si to the above mentioned alloy in a specific amount can further improve the reliability of the solder-bonded portions and strength properties.

The third goal is attainable based on the above discoveries (a) through (f) mentioned above.

The invention, which seeks to attain the first goal, involves the discoveries (a) through (c) and is related to the copper alloy suited for electric components and having high strength and high electric conductivity, consisting of from 0.05 to 0.40% (percentage of alloy components is a weight %) of Cr, from 0.03 to 0.25% of Zr, from 0.10 to 1.80% of Fe, from 0.10 to 0.80% of Ti, and balance of Cu and unavoidable impurities, where the Fe/Ti weight ratio is from 0.66 to 2.6 in a range of from 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 2.6 in a range of from more than 0.60 to 0.80% of Ti, and having 60 μm or less of average grain size. This copper alloy is hereinafter referred to as the first copper alloy and may further contain (a) from 0.05 to 2.0% of Zn and/or (b) from 0.01 to 1% in total of at least one element selected from the group consisting of Sn, In, Mn, P, Mg and Si. The outstanding features of the first copper alloy are that such properties as strength, electric conductivity, chemical etching property, bending formability, and reliability in the solder bonded portions are balanced at a high level.

The invention, which seeks to attain the second goal, involves the discoveries (d) through (f) mentioned above and is related to the copper alloy suited for electrical components and having high strength and high electric conductivity, consisting of from 0.05 to 0.40% of Cr, from 0.03 to 0.25% of Zr, from 0.0005 to less than 0.01% of S, and balance of Cu and unavoidable impurities, and having 60 μm or less of average grain size. This copper alloy is hereinafter referred to as the second copper alloy and may further contain (a) from 0.05 to 2.0% of Zn and/or

(b) from 0.01 to 1% in total of at least one element selected from the group consisting of Sn, In, Mn, P, Mg and Si.

Outstanding features of the second copper alloy are that such properties as strength, electric conductivity, bending
5 formability, press-blanking formability and reliability in the solder bonded portions are balanced at a high level.

The invention, which seeks to attain the third goal, involves the discoveries (a) through (f) and is related to the copper alloy suited for electrical components and having high strength
10 and high electric conductivity, consisting of from 0.05 to 0.40% of Cr, from 0.03 to 0.25% of Zr, from 0.10 to 0.18% of Fe, from 0.10 to 0.90% of Ti, from 0.0005 to less than 0.008% of S, and balance of Cu and unavoidable impurities, where the Fe/Ti ratio is from 0.66 to 2.6 in a range of from 0.10 to 0.60% of Ti and
15 the Fe/Ti ratio is from 1.1 to 2.6 in a range of from more than 0.60 to 0.80% of Ti. This copper alloy is hereinafter referred to as the third copper alloy and may further contain (a) from 0.05 to 2.0% of Zn and/or (b) from 0.01 to 1% in total of at least one element selected from the group consisting of Sn,
20 In, Mn, P, Mg and Si. Outstanding features of the third copper alloy are that such properties as strength, electric conductivity, etching property, bending formability, press-blanking formability and reliability in the solder bonded portions are balanced at a high level.

25

In the first copper alloy, the alloying components and grain size are limited as described above because of the following reasons.

A) Alloying Components

30

(a) Cr

35

Cr precipitates due to aging after the solution heat-treatment in the matrix of the inventive alloy which contains Zr, Ti and Fe in addition to Cr. Thus, the function of Cr to enhance the strength and electric conductivity is
realized. Cr is present in the alloy in an amount effective to realize such function, that is, at least 0.05%. On the other hand, if the Cr content exceeds approximately 0.30%, the undissolved Cr remains in the matrix even after the solution heat-

treatment. Furthermore, when the Cr content exceeds 0.40% coarse inclusions of Cr in the form of whiskers are observed on the cross section vertical to the rolling surface, when such cross section is chemically etched. Such coarse inclusions impair the chemical etching property and cyclic bending formability required for manufacturing a lead frame. The Cr content is therefore specified to be from 0.05 to 0.40%.

(b) Zr

A function of Zr in the first copper alloy is that it forms a compound with Cu due to the aging treatment and precipitates in the matrix to strengthen it. Zr should be present in the first copper alloy in an amount effective for realizing such function, i.e., 0.03% or more. On the other hand, if the Zr content is greater than 0.25%, the undissolved Zr remains even after the solution heat-treatment in the matrix, with the result that the electric conductivity and bending formability are impaired. The Zr content is therefore specified to be from 0.03 to 0.25%.

(c) Ti and Fe

Ti and Fe form an intermetallic compound thereof in the matrix of the inventive alloy when it is subjected to aging; as a result, the strength is further enhanced. Ti and Fe are present in the alloy in an amount effective to realize such function, i.e., at least 0.01% each. On the other hand, when the Ti content exceeds 0.80% or the Fe content exceeds 1.80%, the inclusions, whose main components are Ti and Fe, and which are undissolved in the copper-alloy melt, grow to 5 μ m or more, with the result that the etching property of the copper-alloy sheet is seriously impaired.

It is to be noted here that the strength and electric conductivity of the inventive copper alloy greatly vary depending upon the Fe/Ti weight ratio even if the sum of Ti and Fe contents is equal. More specifically, the electric conductivity greatly lowers, when the Fe/Ti weight ratio is less than 0.66 in a range of from 0.10 to 0.60% of Ti, and, when the Fe/Ti weight ratio is less than 1.1 in a range of from more than 0.60 to 0.80% of Ti. On the other hand, the strength lowers, when the Fe/Ti weight ratio exceeds 2.6 in the total Ti range of from 0.10

to 0.80%. Therefore, the Fe/Ti weight ratio exerts an influence on the electric conductivity and the strength in a manner contrary to one another. The electric conductivity and strength can be balanced at a high level, when the Fe/Ti weight ratio is from 0.66 to 2.6 in a range of from 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 2.6 in a range of from more than 0.60 to 0.80% of Ti. Preferably, the Fe/Ti weight ratio is from 0.66 to 1.7 in a range of from 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 1.7 in a range of from more than 0.60 to 0.80% of Ti, because the strength is higher than attained by adjusting the Fe/Ti Weight ratio to more than 1.7.

The Fe and Ti contents as well as the Fe/Ti ratio are specified as described above, based on the considerations described above, so as to fulfill the requirements of strength, electric conductivity and etching property.

(d) Zn

Zn is added, if necessary, to the inventive alloy, for the purpose of enhancing the heat-resistant peeling property of the solder. Zn is present, if necessary, in an amount effective to realize the above described function, i.e., 0.05% or more. On the other hand, when the Zn content is more than 2.0%, the electric conductivity is lowered. The Zn content is therefore specified to be from 0.05 to 2.0%.

(e) Sn, In, Mn, P, Mg and Si

Sn, In, Mn, P, Mg and Si strengthen the inventive copper alloy mainly due to solution hardening, without incurring excessive reduction in the electric conductivity. One or more of these elements are added, if necessary, to the inventive alloy. In this case, this element(s) are present in the inventive copper alloy in an amount effective to realize the above described function, i.e., 0.01% or more in total. On the other hand, when these element(s) are contained in the inventive alloy in an amount greater than 1.0% in total, the electric conductivity and bending formability are impaired. The content of Sn, In, Mn, P, Mg and/or Si is, therefore, set to be from 0.01 to 1% in total.

B) Grain Size

Grain size of the first copper alloy exerts a great influence upon the bending formability. More specifically, the bending formability, which is measured by the cyclic bending formability herein, is enhanced with the decrease in the grain size. The average grain size is adjusted in the present invention to a value of 60 μm or less. The grain size can be adjusted to a small value by lowering the temperature of the solution heat-treatment, depending on the alloy elements and their concentrations.

In the second copper alloy, the alloying components and grain size are limited to the above described values because for the following reasons.

A) Alloying components

(a) Cr

The function of Cr and reasons for limiting the lower content of Cr are the same as in the first copper alloy. On the other hand, when the Cr content exceeds approximately 0.30%, Cr remains undissolved in the matrix even after the solution heat-treatment. Furthermore, when the Cr content exceeds 0.40%, tailing (that is, metal pieces separated from the burrs) of the press-forming is liable to occur, with the result that stable pressing operation is impeded. The Cr content is therefore set to be from 0.05 to 0.40%.

(b) Zr

The function of Zr and reasons for limiting its content are the same as in the first copper alloy.

(c) S

S forms a non-metallic inclusion in the copper alloys. Along with increase in the S content, cracks are liable to originate from the non-metallic inclusions with the result that the elongation decreases. However, this means that the sheared plane of a workpiece increases and ruptured plane decreases in the press forming. In this case, burrs and shear drop of a workpiece are suppressed. S brings about, therefore, an outstanding improvement in the press-blanking formability, in such a manner that, for example, dimension accuracy of a workpiece is improved. Such improvement is not obtained at S content of less than 0.0005%. On the other hand, when the S

content is more than 0.01%, the elongation decreases and hence the cyclic bending formability is seriously impaired.

(d) Zn

Zn content are the same as in the first copper alloy.

5 (e) Sn, In, Mn, P, Mg and Si

The function of these elements and reasons for limiting their content are the same as in the first copper alloy.

B) Grain Size

Grain size of the first copper alloy exerts a great
10 influence upon the bending formability. More specifically, the bending formability, which is measured by the cyclic bending formability herein, is enhanced with the decrease in the grain size. The average grain size is adjusted in the present invention to a value of 60 μm or less, preferably 40 μm or less. The
15 average grain size of the inventive copper alloy is, therefore, adjusted to 60 μm or less, more preferably to 40 μm or less.

In the third copper alloy, the alloying components and grain size are limited to the above described values for the following reasons.

20 A) Alloying components

(a) Cr

The function of Cr and reasons for limiting the content are the same as in the second copper alloy.

(b) Zr

25 The function of Zr and reasons for limiting the content are the same as in the first copper alloy.

(c) Ti and Fe

The function of Ti and Fe and reasons for limiting the content are the same as in the first copper alloy.

30 (d) S

The function of S and reasons for limiting the content are the same as in the first copper alloy. However, the upper limit value of the S content is 0.008%.

(e) Zn

35 The function of Zn and reasons for limiting the content are the same as in the first copper alloy.

(f) Sn, In, Mn, P, Mg and Si

The function of these elements and reasons for

limiting the content are the same as in the first copper alloy.

B) Grain Size

The reasons for limiting the average grain size are the same as in the first copper alloy.

5 The present invention is hereinafter described more specifically with reference to the examples.

Example 1

Electric copper was used as the starting material and was melted in a high-frequency melting furnace at 1200°C to prepare
10 the copper alloys having various compositions as given in Tables 1 and 2. Each alloy was cast into an ingot, whose surface was scalped. The ingots were then heated to 950°C for 1 hour, and then hot-rolled to 8 mm thick plates. These plates were then subjected to solution heat-treatment at 900°C and to cold-
15 rolling to form 0.3mm thick sheets. Aging was then carried out at 440°C for 12 to 24 hours. Subsequently, cold rolling was carried out to form 0.15mm thick sheets. These sheets were finally stress-relief annealed at 500°C. The average grain size of the resultant sheets was measured. This result is also shown
20 in Tables 1 and 2.

Table 1

Alloy designa- tion	Chemical Components (weight %)											Fe/Ti	Average grain size(μm)
	Cr	Zr	Ti	Fe	Zn	Sn	In	Mn	P	Mg	Si		
Inventive 1	0.21	0.20	0.34	0.55	-	-	-	-	-	-	-	1.6	16
Alloy 2	0.21	0.11	0.49	1.19	0.23	-	-	-	-	-	-	2.4	16
3	0.22	0.12	0.10	0.10	0.21	-	-	-	-	-	-	1	58
4	0.20	0.12	0.68	1.70	0.20	-	-	-	-	-	-	2.5	6
5	0.21	0.11	0.63	0.88	0.24	-	-	-	-	-	-	1.4	10
6	0.18	0.14	0.35	0.55	0.23	-	-	-	-	-	-	1.6	18
7	0.28	0.18	0.33	0.53	0.31	-	-	-	-	-	-	1.6	20
8	0.06	0.13	0.34	0.53	0.21	-	-	-	-	-	-	1.6	17
9	0.21	0.24	0.33	0.55	0.19	-	-	-	-	-	-	1.7	16
10	0.23	0.06	0.34	0.57	0.21	-	-	-	-	-	-	1.7	17
11	0.21	0.11	0.56	0.95	0.93	-	-	-	-	-	-	1.7	21
12	0.22	0.12	0.56	0.97	0.07	-	-	-	-	-	-	1.7	20
13	0.21	0.11	0.21	0.25	0.23	-	-	-	-	-	-	1.2	38
14	0.22	0.12	0.43	0.33	0.21	-	-	-	-	-	-	0.77	26
15	0.20	0.13	0.35	0.64	0.24	-	-	-	-	-	-	1.8	23
16	0.21	0.11	0.56	0.61	0.22	-	-	-	-	-	-	1.1	22
17	0.22	0.13	0.55	0.93	0.21	-	-	-	-	-	-	1.7	14
18	0.06	0.13	0.76	1.48	0.26	-	-	-	-	-	-	1.9	8
19	0.21	0.13	0.22	0.26	0.21	0.1	-	-	-	-	-	1.2	34
20	0.23	0.10	0.45	0.82	0.26	-	-	0.06	-	-	-	1.8	16
21	0.22	0.13	0.24	0.38	0.22	-	0.2	-	-	-	-	1.6	28
22	0.21	0.12	0.43	0.35	0.21	-	-	-	0.2	-	-	0.81	24
23	0.20	0.13	0.53	0.95	0.24	-	-	-	-	0.15	-	1.8	17
24	0.21	0.11	0.35	0.57	0.22	-	-	-	-	-	0.2	1.6	16
25	0.22	0.10	0.37	0.58	0.18	0.1	-	-	-	-	0.1	1.6	14
26	0.23	0.13	0.24	0.38	0.21	-	0.3	-	-	0.1	0.1	1.6	28
27	0.18	0.15	0.23	0.39	0.25	-	-	0.10	0.05	-	0.2	1.7	27
28	0.23	0.14	0.23	0.40	-	-	0.3	-	-	-	-	1.7	27

Remarks: The balance components are Cu and impurities.

Table 2

Alloy designation		Chemical Components (weight %)											Fe/Ti	Average grain size(μm)
		Cr	Zr	Ti	Fe	Zn	Sn	In	Mn	P	Mg	Si		
Comparative Alloy	29	*0.42	0.11	0.34	0.52	0.21	-	-	-	-	-	-	1.5	18
	30	*0.04	0.12	0.33	0.53	0.23	-	-	-	-	-	-	1.6	15
	31	0.19	*0.32	0.33	0.56	0.22	-	-	-	-	-	-	1.7	16
	32	0.20	*0.04	0.32	0.55	0.24	-	-	-	-	-	-	0.58	17
	33	0.25	0.13	*0.85	*1.85	0.21	-	-	-	-	-	-	2	8
	34	0.24	0.14	0.12	*0.07	0.23	-	-	-	-	-	-	0.58	*65
	35	0.21	0.13	0.75	0.77	0.25	-	-	-	-	-	-	*1	12
	36	0.24	0.12	0.22	0.63	0.28	-	-	-	-	-	-	*2.3	24
	37	0.23	0.13	0.43	1.58	0.27	-	-	-	-	-	-	*3.7	13
	38	0.24	0.12	0.44	0.22	0.29	-	-	-	-	-	-	*0.5	23
	39	0.23	0.12	0.62	1.71	0.25	-	-	-	-	-	-	*2.8	9
	40	0.23	0.13	0.61	0.58	0.24	-	-	-	-	-	-	*0.95	11
	41	0.21	0.14	0.35	0.64	*2.20	-	-	-	-	-	-	1.8	16
	42	0.24	0.16	0.42	0.45	0.04	*1.1	-	-	-	-	-	1.1	16
	43	0.21	0.19	0.38	0.44	-	-	*1.4	-	-	-	-	1.2	20
	44	0.25	0.14	0.40	0.41	-	-	-	*1.20	-	-	-	1	18
	45	0.26	0.13	0.45	0.48	-	-	-	-	*1.1	-	-	1.1	14
	46	0.23	0.14	0.47	0.50	-	-	-	-	-	*1.9	-	1.1	17
	47	0.24	0.17	0.42	0.43	-	-	-	-	-	-	*1.8	1	19
	48	0.19	0.09	0.40	0.50	-	-	*1.6	-	0.3	0.8	-	1.3	20

Remarks: The balance components are Cu and impurities.

The asterisk indicates outside the inventive criterion.

With regard to the resultant sheets, the items for evaluating a leadframe, such as tensile strength, elongation, electric conductivity, cyclic bending formability, soldering property, heat-resistant peeling property of solder, Ag plating property and etching property were measured.

Tensile strength and elongation were measured by the tensile test. Electric conductivity was evaluated by conductivity in terms of %IACS. The tensile strength is judged as acceptable when it is 65kgf/mm² or more. The conductivity is judged as acceptable when it is 50%IACS or more.

• Cyclic bending formability was measured by a cyclic bending test, in which a sheet was bent 90 degrees under the condition of bending radius/sheet thickness = 1, and further the bending was repeated in the direction parallel or vertical to the rolling direction. The bending was continued until the sheet ruptured, and the number of bendings was counted, where one forward bending and one reverse bending was counted as one bending. The cyclic bending formability was judged as acceptable (○), when the bending was four times or more, while bending of less than four times was judged as a failure (x).

Soldering property was measured by a surface-tension method using a solder checker. The zero crossing time was measured by the meniscograph. The solder used was 60%Sn-40%Pb, and the temperature of the solder bath was set at 230±5°C. The soldering property was judged as acceptable (○), when the zero crossing time was less than 1 second, while the soldering property was judged as a failure (x) when the zero crossing time was 1 second or longer.

The heat-resistant peeling property of the solder was measured by applying on a test piece a 5 μm thick 90%Sn-10%Pb solderplating, holding the so-treated test piece in air at 150°C for 1000 hours. The holding was interrupted at intervals of 100 hours, and the test piece withdrawn from the holding equipment was bent forward and reverse once at 90° and under a condition of bending radius/sheet thickness = 1. It was then observed whether peeling was present or absent on the bent portion of the plating. The heat-resistant peeling property of the solder was judged as acceptable (○), when the peeling

initiated after 500 hours. The heat resistant peeling property of the solder was judged as failure (x), when the peeling initiated at 500 hours or less.

5 The Ag plating property was measured by applying on the surface of a test piece a 5 μ m thick silver plating, and heating the so-treated test piece at 350°C for 3 minutes in air. It was observed whether swelling is present or absent on the surface of the silver plating. The Ag plating property was judged as acceptable (○), when no swelling occurred. The Ag plating
10 property was judged as failure (x), when swelling occurred.

Chemical etching property was measured by etching a test piece by aqueous ferric chloride solution. The chemically etched surface was observed by a scanning type electronic microscope to measure the maximum size of inclusions. The chemical etching
15 property was judged as good (◎), acceptable (○), and failure (x), when the maximum size of inclusions was less than 1 μ m, from 1 to less than 5 μ m, and 5 μ m or more, respectively.

Table 3

Alloy Designation	Tensile strength	Elongation (%)	Electric conductivity (%IACS)	Cyclic bending formability		Solder- ing Pro-	Initiat- ing time of solder peeling	Ag plating property	Maximum size of inclusion
				Parallel direction	Vertical direction				
Inventive	1	69.1	7.0	63.9	○	○	○	○	○
Alloy	2	65.2	8.9	66.4	○	○	○	○	○
	3	65.0	9.1	65.8	○	○	○	○	○
	4	69.0	8.2	56.5	○	○	○	○	○
	5	70.2	7.3	50.3	○	○	○	○	○
	6	68.1	8.4	65.6	○	○	○	○	○
	7	71.2	6.8	62.4	○	○	○	○	○
	8	65.4	8.0	68.1	○	○	○	○	○
	9	70.5	6.8	64.0	○	○	○	○	○
	10	68.1	8.6	68.3	○	○	○	○	○
	11	66.4	7.9	53.4	○	○	○	○	○
	12	66.3	8.4	58.5	○	○	○	○	○
	13	69.6	8.2	60.2	○	○	○	○	○
	14	72.4	9.3	53.3	○	○	○	○	○
	15	70.4	8.6	66.2	○	○	○	○	○
	16	71.2	9.0	52.3	○	○	○	○	○
	17	67.4	9.2	57.4	○	○	○	○	○
	18	69.5	8.9	51.2	○	○	○	○	○
	19	72.3	7.8	65.3	○	○	○	○	○
	20	66.2	8.2	68.1	○	○	○	○	○
	21	65.1	7.7	67.2	○	○	○	○	○
	22	74.1	7.2	51.2	○	○	○	○	○
	23	68.1	8.1	55.2	○	○	○	○	○
	24	69.6	7.9	64.3	○	○	○	○	○
	25	70.1	7.5	63.9	○	○	○	○	○
	26	67.1	7.5	65.2	○	○	○	○	○
	27	68.2	7.2	64.3	○	○	○	○	○
	28	65.5	7.4	67.4	○	○	○	○	○

Table 4

Alloy designation	Tensile strength	Elongation	Electric conductivity	Cyclic bending formability		Soldering property	Initiating time of solder	Ag plating property	Maximum size of inclusion
				Parallel direction	Vertical direction				
	(kg/mm ²)	(%)	(%IACS)				peeling		
Comparative Alloy	2968.3	5.5	65.4	×	×	○	○	○	×
30	61.3	8.6	68.3	○	○	○	○	○	○
31	72.1	5.1	61.3	×	×	○	○	○	○
32	61.8	7.2	66.8	○	○	○	○	○	○
33	71.4	7.8	42.0	×	×	○	○	×	×
34	58.0	5.2	67.6	×	×	○	○	○	○
35	73.2	7.5	32.5	○	○	○	○	○	○
36	58.5	8.5	68.2	○	○	○	○	○	○
37	50.2	8.9	70.2	○	○	○	○	○	○
38	70.8	8.0	45.0	○	○	○	○	○	○
39	61.7	8.2	41.3	○	○	○	○	○	○
40	72.3	7.2	36.5	○	○	○	○	○	○
41	67.2	8.3	49.5	○	○	○	○	○	○
42	69.5	7.2	48.1	×	×	○	×	○	○
43	67.5	7.5	49.7	×	×	○	×	○	○
44	68.6	6.9	48.7	×	×	○	×	○	○
45	69.3	6.3	48.1	×	×	○	×	○	○
46	70.1	6.2	42.1	×	×	○	×	○	○
47	68.9	5.9	43.2	×	×	○	×	○	○
48	69.5	4.9	45.1	×	×	○	×	○	○

The following facts are clear from the results shown in Tables 3 and 4.

5 Every one of the inventive alloys No. 1-28 exhibits 65kgf/mm² or more of tensile strength and 50%IACS or more of electric conductivity. In addition, the cyclic bending formability, the soldering property, the heat resistant peeling property of solder, the Ag plating property and the etching property in terms of maximum size of inclusions are all acceptable or good.

10 Contrary to this, the comparative alloy No. 29 has a Cr content exceeding the upper limit value specified in the present invention, generating inclusions as coarse as 5 μ m or more and hence the etching property failed. Furthermore, the cyclic bending formability also fails due to the coarse inclusions.

15 The comparative alloy No. 30 has a Cr content lower than the lower limit value specified in the present invention, and hence, the tensile strength is less than 65kgf/mm² and very low.

20 The comparative alloy No. 31 has a Zr content exceeding the upper limit value specified in the present invention, and hence, the cyclic bending formability fails. The comparative alloy No. 32 has a Zr content lower than the lower limit value specified in the present invention, and hence, the strength is very low.

25 The comparative alloy No. 33 has Ti and Fe contents exceeding the upper limit values specified in the present invention, and hence, the electric conductivity is lower than 50%IACS; further, the cyclic bending formability, the Ag plating property and the etching property fail.

30 The comparative alloys No. 35, 38 and 40 have Fe/Ti weight ratio less than the lower limit value specified in the present invention, and hence, the electric conductivity is lower than 50%IACS. On the other hand, the comparative alloys No. 36, 37 and 39 have Fe/Ti weight ratio exceeding the upper limit value specified in the present invention, and hence, the strength is less than 65kgf/mm² and very low.

35 The comparative alloys No. 42 through 48 have Sn, In, Mn, P, Mg and Si contents exceeding the upper limit value

specified in the present invention and, therefore, the electric conductivity is low.

The comparative alloy No. 34 has an average grain size greater than 60 μm , that is, exceeding the inventive specified value, and hence the cyclic bending formability fails.

The comparative alloy No. 41 has a Zn content exceeding the upper limit value specified in the present invention. The electric conductivity of the resultant sheet therefore fails.

Example 2 (the examples of the second copper alloy).

The copper alloys having various compositions as shown in Table 5 were formed into the final product in the form of a 0.15mm thick sheet by the method of Example 1 except that the aging temperature was 400°C. The same testing methods as in Example 1 were carried out to evaluate the evaluation items of a leadframe, i.e., tensile strength, elongation, electric conductivity, cyclic bending formability, soldering property, heat-resistant peeling property of solder, and Ag plating property.

The press-blanking formability, which is one of the evaluation items of a leadframe, was tested by breaking a test piece by a press machine, and the broken surface was then observed by an optical microscope. Evaluation of this formability was made by presence or absence of burrs and the shear cross-sectional percentage as defined below. One criterion for judging the press-blanking formability is that it is acceptable (○) or failure (x), when the shear cross-sectional percentage is 80% or more or less than 80%, respectively. The other criterion for judging the press-blanking formability is that it is acceptable (○) or failure (x) when a burr is absent or present, respectively.

The shear cross-sectional percentage is defined by:
$$\frac{(\text{sheared cross-sectional area of a test piece})}{(\text{fractured cross-sectional area of test piece} + \text{sheared cross-sectional area of a test piece})} \times 100(\%)$$

The evaluation results are shown in Table 6.

Table 5

Alloy designation	Chemical Components (weight %)										Average grain size (μm)
	Cr	Zr	S	Zn	Sn	In	Mn	P	Mg	Si	
Inventive Alloy	51	0.18	0.15	0.0030	-	-	-	-	-	-	20
	52	0.20	0.12	0.0015	0.21	-	-	-	-	-	26
	53	0.25	0.20	0.0032	0.19	-	-	-	-	-	12
	54	0.16	0.19	0.0045	0.11	-	-	-	-	-	21
	55	0.34	0.22	0.0054	0.68	-	-	-	-	-	7
	56	0.19	0.15	0.0040	0.27	-	-	-	0.10	-	11
	57	0.34	0.22	0.0082	0.37	-	0.09	-	-	0.10	8
	58	0.20	0.15	0.0095	0.23	-	0.11	-	0.05	-	10
	59	0.29	0.23	0.0071	0.11	0.30	-	-	-	-	9
	60	0.35	0.22	0.0098	0.22	0.12	-	0.04	-	0.02	10
	61	0.35	0.08	0.0062	0.29	-	-	-	-	-	11
	62	0.19	0.20	0.0031	-	-	-	0.02	-	-	12
Comparative Alloy	63	0.18	0.08	*-	0.28	-	-	-	-	-	38
	64	0.27	*0.26	*-	0.12	-	-	-	-	-	8
	65	0.15	0.20	*0.0003	0.12	-	-	-	-	-	18
	66	0.35	0.21	*-	0.72	-	-	-	-	-	12
	67	0.18	0.11	*-	0.28	-	-	-	0.05	-	10
	68	0.36	0.14	*-	0.35	-	0.06	-	-	0.08	23
	69	0.24	*0.03	*-	0.25	0.1	0.02	-	0.03	-	*45
	70	0.35	0.22	*-	0.08	0.30	-	-	-	-	16
	71	0.36	0.22	*-	0.18	0.10	-	0.03	-	0.02	15
	72	0.38	0.12	*-	-	-	-	0.02	-	-	18
	73	0.32	0.15	*-	0.31	-	-	0.04	0.04	-	18
	74	*0.02	0.21	*-	0.14	-	-	-	-	-	18
	75	*0.41	0.21	*-	0.33	-	0.02	-	-	0.06	10
	76	0.23	0.21	*-	*2.1	0.36	-	-	-	-	19
	77	0.13	0.14	*-	0.17	0.13	-	0.02	0.01	*1.1	16
	78	0.37	0.10	*0.015	0.31	-	-	-	-	0.05	14
	79	0.34	0.19	*0.013	0.12	-	0.08	0.02	0.04	-	14
	80	0.25	*0.02	*0.011	0.24	-	0.08	-	-	0.09	36
	81	0.24	0.13	*0.011	0.17	-	*0.92	-	-	-	13
	82	0.33	0.23	*0.012	0.46	0.08	-	*1.2	-	0.02	12

Remarks: The balance components are Cu and impurities.

The asterisk indicates outside the inventive criterion.

Table 6

Alloy designation	Tensile strength	Elongation	Electric conductivity	Cyclic bending formability	Soldering property	Initiating time of solder peeling	Ag plating property	Shear cross section	Occurrence of burr
	(kgf/mm ²)	(%)	(%IACS)	Para- llel direc- tion	Verti- cal direc- tion			(area %)	
Inven- tive Alloy	51	62.2	7	73	○	○	○	○	○
	52	61.2	6	77	○	○	○	○	○
	53	62.7	7	72	○	○	○	○	○
	54	64.8	7	68	○	○	○	○	○
	55	69.9	7	73	○	○	○	○	○
	56	62.2	7	70	○	○	○	○	○
	57	66.3	7	69	○	○	○	○	○
	58	62.4	4	72	○	○	○	○	○
	59	67.1	6	72	○	○	○	○	○
	60	66.2	6	68	○	○	○	○	○
	61	65.7	6	71	○	○	○	○	○
	62	63.3	7	72	○	○	○	○	○
Compara- tive Alloy	63	58.4	7	82	○	○	○	×	×
	64	63.4	6	74	×	×	○	×	×
	65	64.4	7	54	○	○	○	×	×
	66	60.4	7	68	○	○	○	×	×
	67	60.4	8	69	○	○	○	×	×
	68	65.4	4	63	○	○	○	×	×
	69	55.3	8	79	×	×	○	×	×
	70	61.3	9	77	○	○	○	×	×
	71	67.5	8	71	○	○	○	×	×
	72	63.7	7	72	○	○	×	×	×
	73	63.7	9	74	○	○	○	×	×
	74	52.5	9	81	○	○	○	×	×
	75	64.3	3	74	×	×	○	×	×

Table 6 (continued)

Table 6 (coutinaed)											
Alloy desig- nation	Tensile strength	Elon- gation	Electric conducti- vity	Cyclic bending <u>formability</u> Para- Verti- llel direc-	Cyclic bending <u>formability</u> Verti- cal direc-	Solder- ing pro- perty	Initiat- ing time of solder peeling	Ag plating pro- perty	Shear cross sec- tion	Occur- rence of burr	
	(kgf/mm ²)	(%)	(%IACS)	tion	tion					(area %)	
Com- 76	66.1	9	53	×	×	○	○	○	×	×	
para 77	60.5	10	64	×	×	○	○	○	×	×	
tive 78	67.8	4	71	×	×	○	○	×	○	○	
Alloy 79	62.4	5	76	×	×	○	○	×	○	○	
80	54.9	4	70	×	×	○	○	×	○	○	
81	63.6	7	62	×	×	○	○	×	○	×	
82	64.3	5	63	×	×	○	○	×	○	×	

The following facts are clear from the results shown in Table 6.

Every one of the inventive alloys No. 51-62 exhibits 61.0 kgf/mm² or more of tensile strength and approximately 70%IACS or more of electric conductivity. In addition, the shear cross-sectional percentage is great, and no burrs occur. Furthermore, the cyclic bending formability, the soldering property, the heat-resistant peeling property and the Ag plating property are acceptable.

Contrary to this, the comparative alloys No. 63-80 are free of S or have S content less than the lower limit value specified in the present invention. The shear cross-sectional percentage is small and burrs occur in every one of these comparative alloys.

The comparative alloys No. 81 and 82 have S content greater than the upper limit value specified in the present invention and have, further, the total content of Sn, In, Mn, P, Mg and Si greater than the upper limit value specified in the present invention. Burrs therefore occur. The cyclic bending formability and the Ag plating property therefore fail.

The comparative alloys No. 64 and 75 have Cr and Zr contents greater than the upper limit value specified in the present invention and, therefore, the cyclic bending formability fails, and burrs occur.

The comparative alloys No. 69 and 80 have Zr contents less than the lower limit value specified in the present invention and, therefore, the strength is low.

The comparative alloy No. 76 has Zn content exceeding the upper limit value specified in the present invention and, therefore, the electric conductivity is low.

The comparative alloy No. 77 has the total content of Sn, In, Mn, P, Mg and Si greater than the upper limit value specified in the present invention. As a result, the electric conductivity is low, burrs occur, and the cyclic bending formability fails.

Example 3 (the examples of the third copper alloy)

The copper alloys having various compositions as shown in Tables 7 and 8 were formed into the final product in the

form of a 0.15mm thick sheet by the method of Example 1. The average grain size of the resultant sheets was measured. This result is also shown in Table 7 and 8. The same testing method as in Example 1 was carried out to evaluate the evaluation items of leadframe, i.e., tensile strength, elongation, electric conductivity, cyclic bending formability, soldering property, the heat resistant peeling property of solder, Ag plating property, and press-blanking formability. Here, the tensile strength, the elongation, the electric conductivity, the cyclic bending formability, the soldering property, the heat resistant peeling property of solder, and the Ag plating property were evaluated by the same criteria as in Example 1. The press-blanking formability was evaluated by the same criterion as in Example 2. The evaluation results are shown in Tables 9 and 10.

Table 7

Alloy designation	Chemical Components (weight %)													Average grain size	
	Cr	Zr	Ti	Fe	S	Zn	Sn	In	Mn	P	Mg	Si	Fe/Ti	(μm)	
Inventive Alloy	91	0.16	0.18	0.37	0.60	0.0055	-	-	-	-	-	-	1.6	15	
	92	0.25	0.18	0.11	0.12	0.0006	0.18	-	-	-	-	-	1.1	52	
	93	0.22	0.15	0.69	1.72	0.0019	0.15	-	-	-	-	-	2.5	8	
	94	0.15	0.20	0.36	0.59	0.0059	0.11	-	-	-	-	-	1.6	15	
	95	0.18	0.09	0.25	0.26	0.0035	0.09	-	-	-	-	-	1.0	42	
	96	0.20	0.10	0.45	0.29	0.0052	0.22	-	-	-	-	-	0.6	25	
	97	0.25	0.15	0.53	0.91	0.0069	0.25	-	-	-	-	-	1.7	12	
	98	0.07	0.14	0.79	1.45	0.0007	0.29	-	-	-	-	-	1.8	11	
	99	0.18	0.11	0.25	0.27	0.0045	0.19	0.15	-	-	-	-	1.1	31	
	100	0.22	0.09	0.43	0.85	0.0078	0.22	-	-	0.07	-	-	1.9	15	
	101	0.25	0.12	0.25	0.40	0.0059	0.19	-	0.16	-	-	-	1.6	25	
	102	0.19	0.13	0.45	0.38	0.0031	0.25	-	-	-	-	-	0.8	29	
	103	0.24	0.12	0.55	0.93	0.0068	0.20	-	-	-	-	0.13	1.7	15	
	104	0.22	0.09	0.37	0.53	0.0028	0.28	-	-	-	-	-	0.22	1.4	14
	105	0.16	0.14	0.22	0.42	0.0075	0.22	-	-	0.12	0.02	-	0.23	1.9	25
	106	0.20	0.10	0.26	0.27	0.0040	-	-	-	-	-	-	-	1.0	30
Comparative Alloy	107	0.22	0.12	0.10	0.10	*	0.21	-	-	-	-	-	1	58	
	108	0.20	0.12	0.68	1.70	*	0.20	-	-	-	-	-	2.5	6	
	109	0.18	0.14	0.35	0.55	*	0.23	-	-	-	-	-	1.6	18	
	110	0.21	0.11	0.21	0.25	*	0.23	-	-	-	-	-	1.2	38	
	111	0.22	0.12	0.43	0.33	*	0.21	-	-	-	-	-	0.77	26	
	112	0.22	0.13	0.55	0.93	*	0.21	-	-	-	-	-	1.7	14	
	113	0.06	0.13	0.76	1.48	*	0.26	-	-	-	-	-	1.9	8	
	114	0.21	0.13	0.22	0.26	*	0.21	0.1	-	-	-	-	1.2	34	
	115	0.23	0.10	0.45	0.82	*	0.26	-	-	0.06	-	-	1.8	16	
	116	0.22	0.13	0.24	0.38	*	0.22	-	0.2	-	-	-	1.6	28	
	117	0.21	0.12	0.43	0.35	*	0.21	-	-	-	0.2	-	0.81	24	
	118	0.20	0.13	0.53	0.95	*	0.24	-	-	-	-	0.15	1.8	17	
	119	0.21	0.11	0.35	0.57	*	0.22	-	-	-	-	-	0.2	1.6	16
	120	0.18	0.15	0.23	0.39	*	0.25	-	-	0.1	0.05	-	0.2	1.7	27
	121	*0.42	0.11	0.34	0.52	*	0.21	-	-	-	-	-	-	1.5	18
	122	0.19	*0.32	0.33	0.56	*	0.22	-	-	-	-	-	-	1.8	16
	123	0.20	*0.02	0.32	0.55	*	0.24	-	-	-	-	-	-	1.7	17
	124	0.25	0.13	*0.85	1.70	*	0.21	-	-	-	-	-	-	2	8
	125	0.24	0.14	0.12	*0.10	*	0.23	-	-	-	-	-	-	0.58	*65

Remarks: The balance components are Cu and impurities.

The asterisk indicates outside the inventive criterion.

Table 8

Alloy designation	Chemical Components (weight %)												Fe/Ti	Average grain size (μm)
	Cr	Zr	Ti	Fe	S	Zn	Sn	In	Mn	P	Mg	Si		
Comparative Alloy	126	0.21	0.13	0.75	0.77	*	0.25	-	-	-	-	-	*1	12
	127	0.24	0.12	0.22	0.63	*	0.28	-	-	-	-	-	*2.8	24
Alloy	128	0.23	0.13	0.43	1.58	*	0.27	-	-	-	-	-	*3.7	13
	129	0.24	0.12	0.44	0.22	*	0.29	-	-	-	-	-	*0.5	23
	130	0.23	0.12	0.62	1.71	*	0.25	-	-	-	-	-	*2.8	9
	131	0.23	0.13	0.61	0.58	*	0.24	-	-	-	-	-	*0.95	11
	132	0.21	0.14	0.35	0.64	*	*2.2	-	-	-	-	-	1.8	16
	133	0.21	0.13	0.37	0.66	*	*0.03	-	-	-	-	-	1.8	18
	134	0.25	0.14	0.40	0.41	*	-	-	*1.2	-	-	-	1	18
	135	0.26	0.13	0.45	0.48	*	0.22	-	-	*1.1	-	-	1.1	14
	136	0.23	0.14	0.47	0.50	*	0.18	-	-	-	*1.9	-	1.1	17
	137	0.19	0.09	0.40	0.51	*	0.21	-	*1.5	-	0.3	0.8	1.3	20
	138	0.24	0.17	0.42	0.43	*	0.14	-	-	-	-	-	1	19
	139	0.24	0.16	0.42	0.45	*	-	*1.1	-	-	-	-	1.1	16
	140	*0.44	0.09	0.33	0.50	*0.0088	0.22	-	-	-	-	-	1.5	15
	141	*0.04	0.12	0.33	0.53	0.0004	0.23	-	-	-	-	-	1.6	15
	142	*0.03	0.11	0.35	0.58	*0.0120	0.19	-	-	-	-	-	1.7	13
	143	0.16	*0.35	0.33	0.60	*0.0098	0.20	-	-	-	-	-	1.8	15
	144	0.18	*0.02	0.38	0.59	*0.0085	0.19	-	-	-	-	-	1.6	25
	145	0.25	0.11	*0.87	1.75	*0.0150	0.19	-	-	-	-	-	2	7
	146	0.22	0.11	0.11	*0.09	*0.0091	0.18	-	-	-	-	-	0.82	70
	147	0.22	0.11	0.76	0.80	*0.0082	0.21	-	-	-	-	-	*1.1	15
	148	0.22	0.12	0.24	0.66	*0.0099	0.25	-	-	-	-	-	*2.8	20
	149	0.21	0.11	0.42	1.65	*0.0150	0.20	-	-	-	-	-	*3.9	15
	150	0.22	0.13	0.40	0.18	*0.0083	0.22	-	-	-	-	-	*0.45	29
	151	0.22	0.11	0.60	1.62	*0.0112	0.19	-	-	-	-	-	*2.7	10
	152	0.19	0.13	0.65	0.60	*0.0160	0.12	-	-	-	-	-	0.92	15
	153	0.23	0.15	0.38	0.69	*0.0170	*2.5	-	-	-	-	-	1.8	20
	154	0.22	0.16	0.39	0.70	*0.0093	*0.01	-	-	-	-	-	1.8	21
	155	0.22	0.15	0.42	0.46	*0.0085	-	-	*1.35	-	-	-	1.1	12
	156	0.23	0.11	0.48	0.51	*0.0090	0.20	-	-	*1.3	-	-	1.1	20
	157	0.22	0.12	0.48	0.53	*0.0110	0.11	-	-	-	*2.2	-	1.1	12
	158	0.15	0.12	0.42	0.52	*0.0082	0.28	-	*1.8	-	0.9	0.5	1.2	19
	159	0.22	0.15	0.44	0.44	*0.0085	0.15	-	-	-	-	-	1	20
	160	0.25	0.18	0.42	0.44	*0.0093	-	*1.2	-	-	-	-	1	19

Remarks: The balance components are Cu and impurities.

The asterisk indicates outside the inventive criterion.

Table 9

Alloy desig- nation	Tensile strength	Elon- gation	Electric conducti- vity	Cyclic bending formability	Solder- ing pro- perty	Initiat- ing time of solder peeling	Ag plating proper- ty	Shear cross Sec- tion	Occur- rence of burr
	(kgf/mm ²)	(%)	(%IACS)	Para- llel Direc-	Verti- cal Direc-			(area %)	
Inventive Alloy	91	67.7	8.3	65.2	○	○	○	○	○
	92	65.8	8.8	66.5	○	○	○	○	○
	93	68.5	7.9	55.8	○	○	○	○	○
	94	68.5	8.1	64.9	○	○	○	○	○
	95	67.2	8.2	61.5	○	○	○	○	○
	96	72.9	8.8	50.2	○	○	○	○	○
	97	68.9	8.5	55.6	○	○	○	○	○
	98	69.2	8.5	51.2	○	○	○	○	○
	99	73.2	6.9	52.5	○	○	○	○	○
	100	65.5	8.5	69.2	○	○	○	○	○
	101	65.0	7.5	68.2	○	○	○	○	○
	102	73.2	7.0	50.2	○	○	○	○	○
	103	69.2	6.8	52.1	○	○	○	○	○
	104	70.5	7.2	62.1	○	○	○	○	○
	106	66.4	7.0	66.1	○	○	○	○	○
	106	73.8	6.7	53.5	○	○	○	○	○
Compara- tive Alloy	107	65.0	9.1	65.8	○	○	○	×	×
	108	69.0	8.2	56.5	○	○	○	×	×
	109	68.1	8.4	65.6	○	○	○	×	×
	110	69.6	8.2	60.2	○	○	○	×	×
	111	72.4	9.3	53.3	○	○	○	×	×
	112	67.4	9.2	57.4	○	○	○	×	×
	113	69.5	8.9	50.1	○	○	○	×	×
	114	72.3	7.8	54.3	○	○	○	×	×
	115	66.2	8.2	68.1	○	○	○	×	×

Table 9 (continued)

Alloy desig- nation	Tensile strength	Elon- gation	Electric conducti- vity	Cyclic bending formability	Solder- ing pro- perty	Initiat- ing time of solder peeling	Ag plating proper- ty	Shear cross Sec- tion	Occur- rence of burr	
	(kgf/mm ²)	(%)	(%IACS)	Para- llel Direc-	Verti- cal Direc-			(area %)		
Compara- tive Alloy	116	65.1	7.7	67.2	○	○	○	○	×	×
	117	74.1	7.2	51.2	○	○	○	○	×	×
	118	68.1	8.1	64.1	○	○	○	○	×	×
	119	69.6	7.9	64.3	○	○	○	○	×	×
	120	68.2	7.2	64.3	○	○	○	○	×	×
	121	68.3	5.5	65.4	×	×	○	○	○	×
	122	72.1	5.1	61.3	×	×	○	○	○	×
	123	61.8	7.2	66.8	○	○	○	○	×	×
	124	71.4	7.8	42.0	×	×	○	○	×	×
	125	58.0	5.2	67.6	×	×	○	○	○	×
Compara- tive Alloy	126	73.2	7.5	32.6	○	○	○	○	×	×
	127	58.5	8.5	68.2	○	○	○	○	×	×
	128	50.2	8.9	70.2	○	○	○	○	×	×
	129	70.8	8.0	45.0	○	○	○	○	×	×
	130	61.7	8.2	41.3	○	○	○	○	×	×
	131	72.3	7.2	36.5	○	○	○	○	×	×
	132	67.2	8.3	49.5	○	○	○	○	×	×
	133	65.3	9.2	66.3	○	○	○	×	○	×
	134	68.6	6.9	48.7	×	×	○	×	○	×
	135	69.3	6.3	48.1	×	×	○	○	○	×
	136	70.1	6.2	42.1	×	×	○	○	○	×
	137	69.5	4.9	45.1	×	×	○	○	○	×
	138	68.9	5.9	43.2	×	×	○	○	○	×
	139	69.5	7.2	48.1	×	×	○	×	○	×
	140	68.0	4.0	64.0	×	×	○	○	×	○

Table 10

Alloy designation	Tensile strength		Elongation	Electric conductivity	Cyclic bending formability		Soldering property	Initiating time of solder peeling	Ag plating property	Shear cross section	Occurrence of burr
	(kgf/mm ²)	(%)	(%IACS)	Parallel	Vertical					(area %)	
Comparative alloy	141	61.3	8.6	68.3	○	○	○	○	○	×	○
	142	60.9	4.9	69.9	×	×	○	○	×	○	○
	143	70.8	3.5	61.2	×	×	○	○	×	○	○
	144	60.1	6.5	67.9	×	×	○	○	×	○	○
	145	72.5	4.2	41.0	×	×	○	○	×	○	○
	146	56.5	3.5	67.9	×	×	○	○	×	○	○
	147	71.5	3.7	31.2	×	×	○	○	×	○	○
	148	59.2	5.4	68.5	×	×	○	○	×	○	○
	149	49.2	3.9	69.5	×	×	○	○	×	○	○
	150	69.2	3.4	42.2	×	×	○	○	×	○	○
	151	58.0	2.9	39.8	×	×	○	○	×	○	○
	152	70.5	4.0	34.2	×	×	○	○	×	○	○
	153	66.1	3.5	48.2	×	×	○	○	×	○	○
	154	63.8	3.2	65.2	×	×	○	×	×	○	○
	155	67.4	2.9	45.2	×	×	○	×	×	○	×
	156	67.5	3.8	49.1	×	×	○	○	×	○	×
	157	68.9	2.5	40.1	×	×	○	○	×	○	×
	158	68.5	2.2	46.3	×	×	○	○	×	○	×
	159	67.2	2.2	44.3	×	×	○	○	×	○	○
	160	68.0	3.1	45.8	×	×	○	×	×	○	×

The following facts are clear from the results shown in Tables 9 and 10.

Every one of the inventive alloys No. 91-106 exhibits 65 kgf/mm² or more of tensile strength and 50%IACS or more of electric conductivity. In addition, the shear cross-sectional percentage is great, and no burrs occur. Furthermore, the cyclic bending formability, the soldering property, the heat resistant peeling property and the Ag plating property are all acceptable.

Contrary to this, the comparative alloys No. 107-129 are free of S, and the shear cross-sectional percentage is small and burrs occur in every one of these comparative alloys.

The comparative alloys No. 140 and 142-145 have S content greater than the upper limit value specified in the present invention. The shear cross-sectional percentage is acceptable and no burrs occur in these comparative samples. But the cyclic bending formability and the Ag plating property fail.

The comparative samples No. 150 and 160 have S content exceeding the upper limit value specified in the present invention. They also have the total content of Sn, In, Mn, P, Mg and Si greater than the upper limit value specified in the present invention and, therefore, burrs occur and the cyclic bending formability and the Ag plating property fail.

The comparative alloy No. 141 has an S content less than the lower limit value specified in the present invention. Burrs therefore occur, and the press-blanking formability fails.

The comparative alloys No. 121 and 122 have Cr and Zr contents greater than the upper limit value specified in the present invention and, therefore, the cyclic bending formability fails, and burrs generate.

The comparative alloys No. 141 and 142 have Cr and Zr contents exceeding the upper limit value specified in the present invention and, therefore, the cyclic bending formability fails, and burrs occur.

The comparative alloys No. 141 and 142 have Cr content less than the lower limit value specified in the present invention and, therefore, the tensile strength is less than 65kgf/mm² and hence very low.

The comparative alloys No. 127, 128, 130, 148 and 149 have an Fe/Ti weight ratio greater than the upper limit value specified in the present invention and, therefore, the tensile strength is less than 65kgf/mm^2 and is very low. The comparative alloys No. 126, 129, 150, and 152 have an Fe/Ti weight ratio less than the lower limit value specified in the present invention and, therefore, the electric conductivity is less than 50%IACS and is very low.

The comparative alloys No. 132 and 153 have Zn content exceeding the upper limit value specified in the present invention, and, therefore the electric conductivity is less than 50%IACS and very low.

The comparative alloys No. 134-137 have the total content of Sn, In, Mn, P, Mg and Si greater than the upper limit value specified in the present invention. As a result, the electric conductivity is low, and the cyclic bending formability fails.

The comparative alloy No. 125 has a grain size exceeding $60\text{ }\mu\text{m}$, which is outside the upper limit value specified in the present invention and, therefore, the cyclic bending formability fails.

As is described hereinabove, there is provided a high-strength and high electric-conductive copper alloy which is suited for such electric components as a leadframe and a conductive spring. The present invention, therefore, contributes to enhancement of the performance of the electric appliances and is useful in the industry.

CLAIMS

1. A copper alloy suited for electrical components, containing from 0.05 to 0.40% of Cr and from 0.03 to 0.25% of Zr, and having high strength and high electric conductivity, consisting of, by weight percentage, said Cr, said Zr, from 0.0005 to less than 0.01% of S, from 0.05 to 2.0% of Zn, optionally from 0.01 to 1% in total of at least one element selected from Sn, In, Mn, P, Mg and Si, and/or optionally from 0.10 to 0.80% of Ti together with 0.10 to 1.80% Fe, where the Fe/Ti weight ratio is from 0.66 to 2.6 in a range of from 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 2.6 in a range of more than 0.60 to 0.80% of Ti, and the balance of Cu and unavoidable impurities, and having an average grain size of 60 μ m or less and a microstructure comprising aging precipitates of a Zr-Cu compound, chromium and optionally a Ti-Fe intermetallic compound.
2. A copper alloy according to claim 1, consisting of, by weight percentage, from 0.10 to 1.80% of Fe.
3. A copper alloy according to claim 1 or claim 2, wherein the copper alloy is a rolled sheet having a thickness of from 0.1 to 0.25mm.
4. A copper alloy according to any one of the preceding claims, wherein the Fe/Ti weight ratio is from 0.66 to 1.7 in a range of 0.10 to 0.60% of Ti, and the Fe/Ti weight ratio is from 1.1 to 1.7 in a range of from more than 0.60 to 0.80% of Ti.
5. A copper alloy according to any one of the preceding claims, wherein inclusions included therein have a size of less than 5 μ m.

6. A copper alloy according to claim 5, wherein the size of inclusions is less than 1 μm .

5 7. A copper alloy according to any one of the preceding claims, wherein the average grain size is 40 μm or less.

8. A copper alloy according to any one of the preceding claims, consisting of, by weight percentage, from 0.0005 to less than 0.0080% of S.

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9. A copper alloy according to claim 1 substantially as hereinbefore described.

15 10. A copper alloy according to claim 1 substantially as hereinbefore described in any one of the specific Examples.

11. An electrical component made from a copper alloy according to any one of the preceding claims.

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The
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Office

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Application No: GB 9713358.1
Claims searched: 1-11

Examiner: R.B.Luck
Date of search: 16 July 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.O): C7A

Int CI (Ed.6):

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	EP0492987 (Kabushiki Kaisha Toshiba){See Comparative Examples 1 and 2 in Table 1}	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.